Quality in fives

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CHAPTER 7

EFFECTIVE DECISION SUPPORT FOR NURSE SCHEDULING

The third chapter described three hypotheses. Two of these hypotheses — the hypothesis of formalization and the hypothesis of robustness — have been confirmed. This chapter describes the scheduling experiment, an experiment which was designed to test the third and last hypothesis: the hypothesis of effectiveness. This hypothesis states that the task of nurse scheduling can be effectively supported by means of quality indication.

In the scheduling experiment, nurse schedulers were asked to arrange a nursing schedule for a fictitious nursing unit. This experiment investigates the effect of supporting the nurse schedule with information about the factor values on the quality of the arranged nursing schedules. The following sections discuss the design, results and conclusions of this scheduling experiment.

7.1 DESIGN OF THE SCHEDULING EXPERIMENT

The objective of the scheduling experiment is to test the hypothesis of effectiveness. This hypothesis states that quality indication can be effectively used to support the task of nurse scheduling. To attain this objective, the scheduling experiment was based on a pre-test post-test design. In this design, the pre-test condition concerns the old situation, while the post-test measures the new situation. Both situations are separate steps in the scheduling experiment. Below, the first subsection describes these steps. The second subsection discusses the variables used in this experiment. And the third subsection describes additional characteristics of the East-5 nursing unit, essential for the scheduling experiment.

7.1.1 Steps of the scheduling experiment

In the second step of the scheduling experiment, a number of nurse schedulers were given an initial four-week schedule for the fictitious nursing unit of East-5. This initial schedule resulted from the initialization. In the scheduling experiment, this initialization has already been completed.

In the second step of the scheduling experiment, the nurse schedulers were asked to arrange a high-quality nursing schedule for this nursing unit on the basis of this initial schedule with the assistance of a nurse scheduling support system (i.e. the ZKR system; see also Appendix C). This step is called 'traditional scheduling', and the results of this step are called the 'original final schedule'.

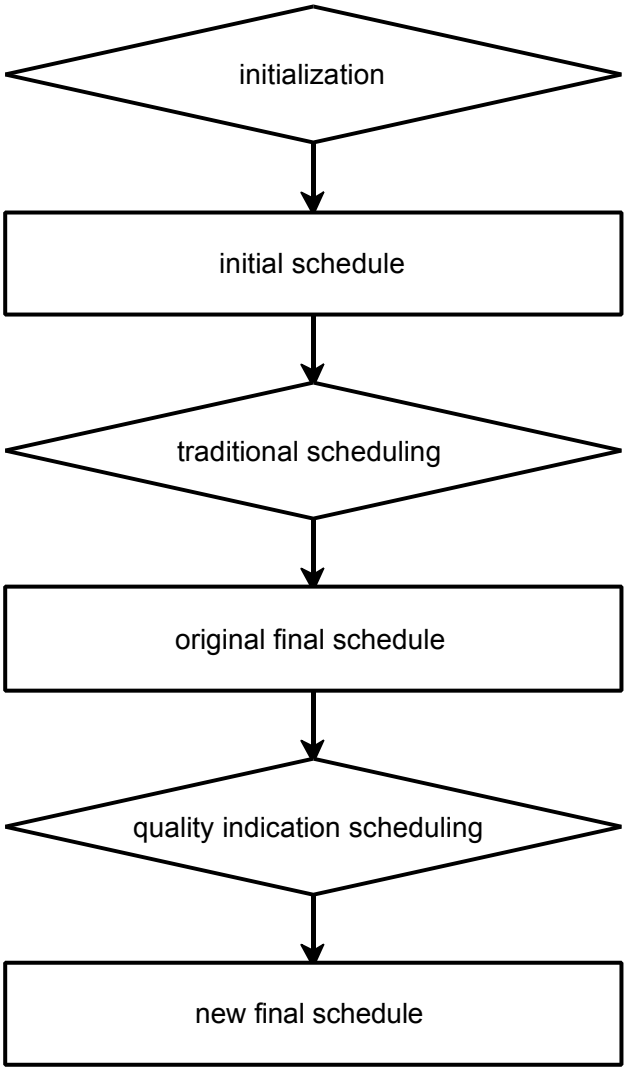
Normally, nurse scheduling only involves the two steps mentioned above. In the scheduling experiment, a third step is added. In this third step, each nurse scheduler was informed about the factor values of the arranged nursing schedule as computed by an additional software module which computes the values of the quality indicators according to the formulas described in the fifth chapter. Then, the nurse schedulers decided if and how they would use this information to rearrange the original final schedule into a new final schedule. Figure 7.1 shows these three steps of the scheduling experiment and the resulting 'status' of the schedule.

7.1.2 Variables of the scheduling experiment

The objective of the scheduling experiment is to determine the effectiveness of 'quality indication scheduling', the third step discussed above. This effectiveness concerns the quality of the new final schedules compared to the quality of the original final schedules. Therefore, the nursing schedule quality is the dependent variable. This variable will be estimated as a non-weighted sum of the factor values. This estimation does not need the determination of the individual summation weights, which requires an analysis like the one discussed in the previous chapter. An average (i.e. non-weighted) sum of the factor values will provide a valid estimation of the required average value of nursing schedule quality.

Receiving additional quality indication is the independent variable. In the second step of the scheduling experiment, the nurse schedulers did not receive quality indication, whereas they did receive this quality indication in the third step of the scheduling experiment.

Figure 7.1 STEPS OF THE SCHEDULING EXPERIMENT



The difference in nursing schedule quality between the original final schedule (Q^o) and the new final schedule (Q^n) will determine the effectiveness of quality indication. The null hypothesis is that this difference will be zero (H_0: $Q^n - Q^o = 0$), while the alternative hypothesis is that this difference will be greater than zero (H_1 : $Q^n - Q^o > 0$).

7.1.3 Characteristics of the East-5 nursing unit

The nursing staff of the East-5 nursing unit consists of nine registered nurses and fourteen nursing assistants. Some of these twenty-three nurses work full-time. In this study, this means that these nurses have a so-called full-time equivalent of 0.8 or higher. The remaining nurses work part-time, which means that they have a full-time equivalent below 0.8. Table 7.1 shows this division into registered nurses and nursing assistants per full-time equivalent (fte).

Table 7.1 CHARACTERISTICS OF THE EAST-5 NURSING STAFF

	full-time equivalent						total	fte
	1.0	0.9	0.8	0.7	0.6	0.5		
registered nurses	2	2	1	2	2	1	9	7.0
nursing assistants	3	2	2	2	2	3	14	10.5
total	5	4	3	3	4	4	23	17.5

The required total of full-time equivalents of a nursing staff can be computed according to a standard calculation (Excuro, 1993). In this calculation, normal days off, festive days, short-time days, special leaves and educational days are subtracted from the total number of days in a year. Furthermore, this calculation is based on an average illness ratio of five percent. Finally, the holidays are subtracted from this subtotal. Table 7.2 shows this calculation for a nurse with a full-time equivalent of 1.0. This nurse has an average of 203 working days a year. This equals a 'yield' of 203/365 per fte. As table 7.1 shows, the East-5 nursing unit has a total of 17.5 fte. This means that the East-5 nursing unit can provide 272.5 shifts per schedule period of four weeks[1]. And, as described in the last chapter, the East-5 nursing unit requires the assignment of 272 shifts per schedule period of four weeks. Therefore, the East-5 nursing unit has just the size to meet its quantitative staffing demands.

[1] 17.5 fte × 203/365 yield/fte × 28 days = 272.5 shifts

Table 7.2 AVERAGE NUMBER OF ANNUAL WORKING DAYS

	total
total number of days within a year	365
minus number of normal days off	104
minus number of festive days	7
minus number of short-time days	12
minus average number of special leave days a year	1
minus average number of educational days a year	3
minus average number of sick-leave days a year (5% of the above)	12
minus number of holidays a year	23
average number of working days a year	203

7.1.4 Characteristics of the initial schedule

The quantitative staffing demands of the East-5 nursing unit, as described in the previous chapter, require that a total of 272 shifts are scheduled in a four-week schedule period. This total consists of 56 night shifts, 84 evening shifts and 132 day shifts.

The total of full-time equivalents of the East-5 nursing staff determines the maximum number of shifts that can be scheduled at 350. This maximum is computed by multiplying the total number of full-time equivalents by five shifts a week during four weeks.

In the initial schedule used in the scheduling experiment, five nurses had a week of holidays in the four-week schedule period. Furthermore, on eight occasions a nurse was not available for a day on. These holidays and 'not available' days could not be exchanged for a day on (i.e. a day, evening or night shift). This means that there were 340 shifts available, while there were 272 shifts required. This provides some flexibility in arranging the required nursing schedules, which ensures that this experiment would not be too time-consuming to perform.

Figure 7.2

Figure 7.2 THE INITIAL SCHEDULE USED IN THE SCHEDULING EXPERIMENT

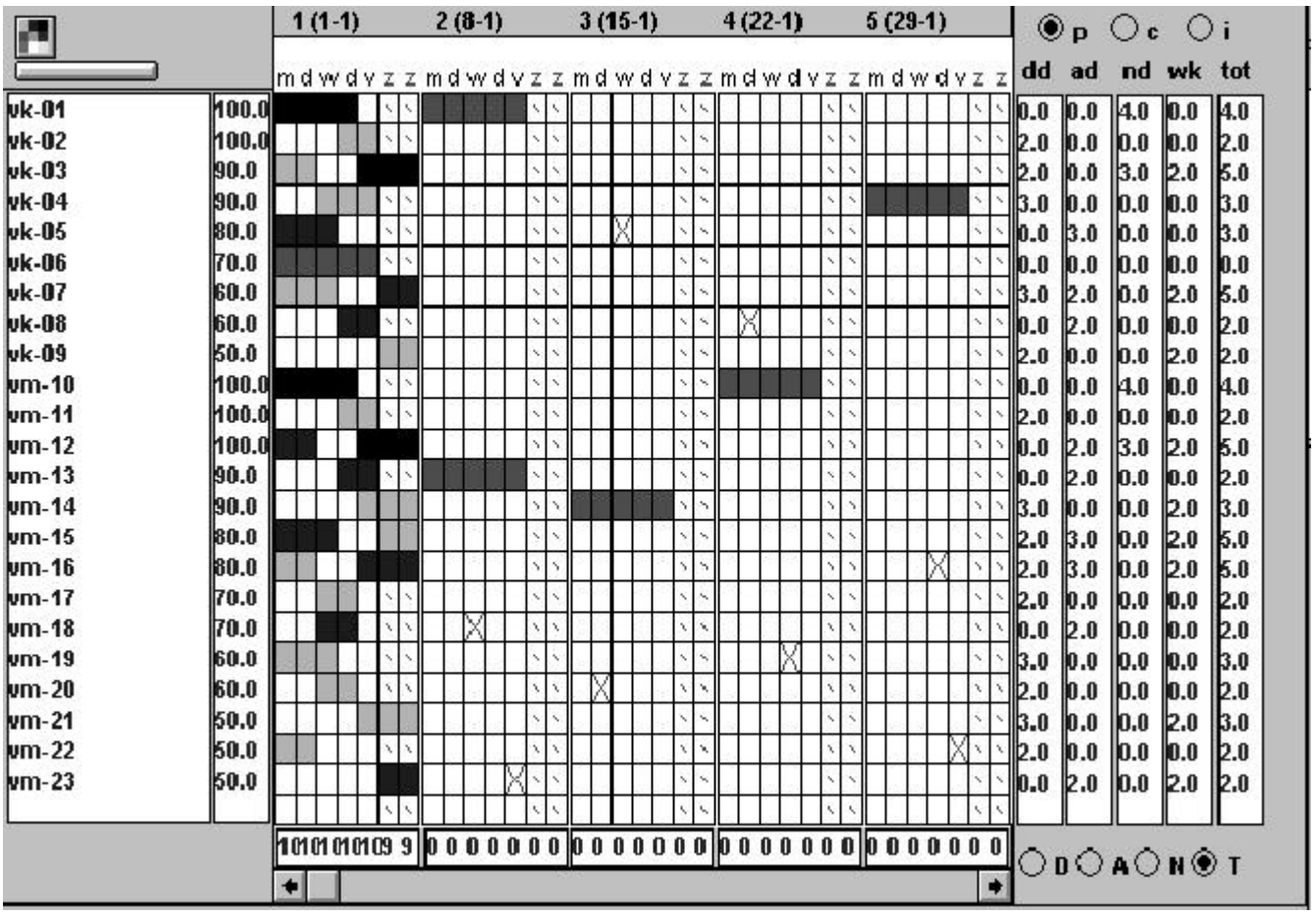


Figure 7.2 shows the initial schedule (as represented by the user interface of the ZKR scheduling support system; see also Appendix C). This initial schedule covers the weeks numbered as 2, 3, 4 and 5. Week number one is the last week of the previous schedule. In this initial schedule, five blocks of five consecutive holidays are represented by dotted rectangles, and the eight crosses represent the 'not available' days. The nursing staff is represented vertically.

7.2 RESULTS OF THE SCHEDULING EXPERIMENT

In total, eight nurse schedulers agreed to participate in the scheduling experiment. This experiment consisted of two parts. In the first part, each of these eight nurse schedulers arranged a nursing schedule. This resulted in eight original final schedules. In the second part, the nurse schedulers received quality indication. This information could be used to rearrange these original final schedules into new final schedules. The section below discusses the resulting factor values of both the original final schedules and the new final schedules.

7.2.1 Values of the original final schedules

In the first part of the scheduling experiment, each of these eight nurse schedulers arranged a nursing schedule in the traditional situation. Table 7.3 shows the factor values of the resulting original final schedules. The five quality factors, completeness, optimality, proportionality, healthiness and continuity, are represented as C, O, P, H and T, respectively.

As described in the previous chapter, the auditing experiment showed an average summation weight of approximately two. Therefore, summation weights of two were used for all quality factors to compute an estimation of the total quality value of a nursing schedule. Table 7.2 also shows these estimated total quality values of the original final schedules, represented as Q^o. Furthermore, table 7.3 shows the mean values (m) and the standard deviations (σ) for each quality factor and for the estimation of the total quality value.

The mean estimated total quality value for these original nursing schedules was nearly five on a scale from one to ten. These values range from 4.4 to 6.2. The arranged original final schedules show that the nurse schedulers differed consider-

ably in the values per quality factor. However, most nurse schedulers scored high on completeness. The scores on continuity and proportionality are mostly second or third in rank. And for half of the arranged original nursing schedules, the scores on optimality are low (i.e. below 0.4). The most remarkable result is the fact that all arranged final schedules scored low on healthiness (i.e. 0.45 or lower).

Table 7.3 FACTOR VALUES OF THE ORIGINAL FINAL SCHEDULES

	C	O	P	H	T	Q
1	0.60	0.41	0.45	0.41	0.37	4.5
2	0.46	0.22	0.48	0.37	0.65	4.4
3	0.56	0.45	0.49	0.45	0.47	4.8
4	1.00	0.35	0.46	0.35	0.49	5.3
5	1.00	0.60	0.62	0.40	0.49	6.2
6	0.56	0.55	0.46	0.28	0.59	4.7
7	0.56	0.36	0.49	0.40	0.40	4.4
8	1.00	0.36	0.41	0.28	0.35	4.8
mean	0.72	0.41	0.48	0.37	0.48	4.9
σ	0.24	0.12	0.06	0.06	0.11	0.6

The eight nurse schedulers differed significantly in the amount of time needed to arrange these original final schedules. The fastest nurse scheduler completed the schedule in slightly more than one hour, whereas the slowest nurse scheduler needed almost two hours to arrange the original final schedule. For this traditional situation, table 7.4 shows the total scheduling time expressed in minutes. This table also shows the mean total scheduling time and its standard deviation, which is represented between rounds.

The computation of the values of each of the quality factors, as described in the previous chapter, is based on the occurrences of a number of low-quality schedule patterns. In total, twenty-one different low-quality schedule patterns are identified. In order to enable a more detailed analysis of the arranged original final schedules, the tables 7.5a and 7.5b show the numbers of occurrences for each of these patterns per arranged nursing schedule. This table also shows the totals per

low-quality schedule pattern and the totals per nurse scheduler. Low-quality schedule patterns with most occurrences are 'day over-qualification' (O4) and 'evening shift followed by day shift' (H7). These results also show that none of the nurse schedulers scheduled more night shifts than required (O6), and just onces, too many consecutive evening shifts (H3) were scheduled. Also only one nurse scheduler scheduled (twice) a single day on (H6).

Table 7.4 TOTAL SCHEDULING TIME IN MINUTES IN THE TRADITIONAL SITUATION

	scheduler								mean	σ
	1	2	3	4	5	6	7	8		
time	62	110	89	68	95	107	108	63	88	21

The eight nurse schedulers differed strongly concerning the number of low-quality schedule patterns that occurred in the original final schedules. These numbers ranged from about twenty to just over hundred.

Table 7.6 shows the summarized number of low-quality schedule patterns per quality factor.

The results of this summarization show that the total number of scheduled low-healthiness schedule patterns was nearly as high as the total of the remaining low-quality schedule patterns. On average, the arranged original final schedules score worst on healthiness and best on completeness.

Figure 7.3 shows one of the arranged original final schedules. The black rectangles represent night shifts. The day shifts are represented by the lightly-dotted rectangles. And the remaining, grey-dotted rectangles represented evening shifts. The scheduled holidays and days off were removed for ease of survey.

The original final schedule shown in figure 7.3 has the highest total quality value compared with the other original final schedules. However, this schedule has a low value on healthiness. This can be illustrated by the seven occurrences of an evening shift followed by a day shift, which strongly decreases the healthiness of this schedule.

Table 7.5a NUMBERS OF OCCURRENCES OF LOW-QUALITY SCHEDULE PATTERNS IN ORIGINAL FINAL SCHEDULES

	schedules								
	1	2	3	4	5	6	7	8	total
completeness:									
day incompleteness	1	0	0	0	0	1	0	0	2
evening incompleteness	0	0	1	0	0	1	1	0	3
night incompleteness	0	3	0	0	0	0	0	0	3
optimality:									
day under-qualification	0	6	0	2	1	1	2	3	15
evening under-qualification	0	3	0	0	0	0	1	0	4
night under-qualification	0	3	0	0	0	0	0	0	3
day over-qualification	12	23	10	15	0	0	17	16	93
evening over-qualification	0	13	0	8	0	1	0	4	26
night over-qualification	0	0	0	0	0	0	0	0	0
proportionality:									
single day off	2	2	3	1	0	4	1	7	20
double weekend on	6	4	1	5	1	2	3	4	26
triple weekend on	1	0	0	1	0	0	1	0	3

Table 7.5b NUMBERS OF OCCURRENCES OF LOW-QUALITY SCHEDULE PATTERNS IN ORIGINAL FINAL SCHEDULES

	schedules								
	1	2	3	4	5	6	7	8	total
healthiness:									
too many consecutive days on	0	0	0	4	1	10	1	2	18
too many consecutive day shifts	2	9	1	7	1	0	0	3	23
too many consecutive evening shifts	0	0	0	0	0	1	0	0	1
too many consecutive night shifts	0	12	4	0	0	24	0	0	40
too few days off after night shifts	5	3	3	4	3	0	7	14	39
single day on	0	0	0	0	0	0	0	2	2
evening shift followed by day shift	7	0	1	15	11	26	9	40	109
continuity:									
semi-discontinuity	6	1	3	4	5	2	4	2	27
full-discontinuity	2	0	1	1	0	0	2	4	10
total (table 7.5a + table 7.5b)	44	82	28	67	23	73	49	101	467

Figure 7.3 THE ORIGINAL FINAL SCHEDULE ARRANGED BY NURSE SCHEDULER NUMBER FIVE

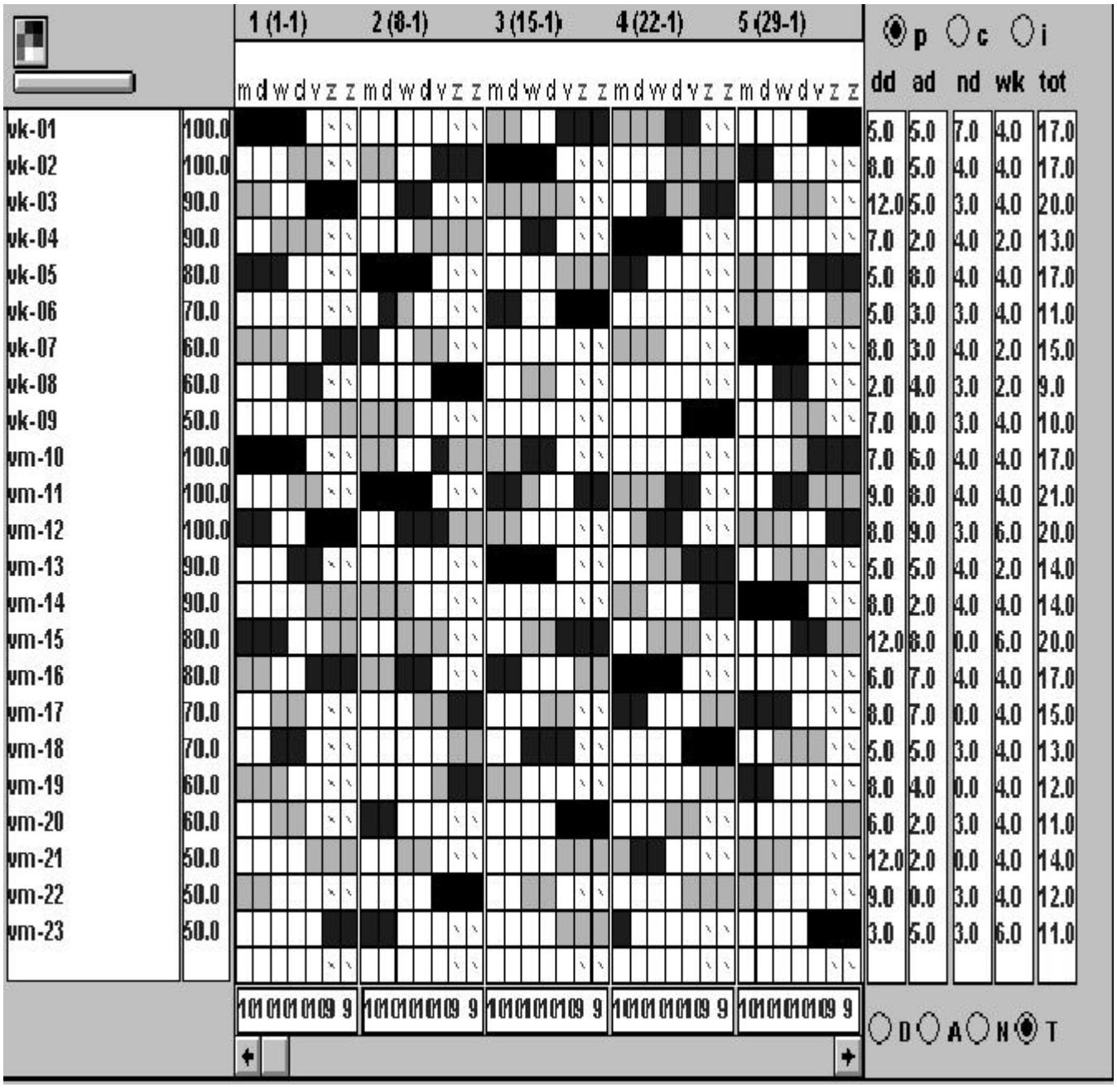


Table 7.6 SUMMARIZED NUMBER OF LOW-QUALITY SCHEDULE PATTERNS PER QUALITY FACTOR IN ORIGINAL FINAL SCHEDULES

	schedules								
	1	2	3	4	5	6	7	8	total
C	1	3	1	0	0	2	1	0	8
O	12	48	10	17	1	2	20	23	141
P	9	6	4	7	1	6	5	11	49
H	14	24	9	30	16	61	17	61	232
T	8	1	4	5	5	2	6	6	37

7.2.2 Values of the new final schedules

In the following stage of the scheduling experiment, each nurse scheduler was informed about the values of the five quality factors of the arranged nursing schedule. On the basis of the quality indication, each of the eight nurse schedulers rearranged the original final schedule into a new final schedule. Table 7.7 shows the factor values and estimations of the total quality values of these new final schedules. Table 7.7 also shows the differences in the estimation of the total quality value per nurse schedule between the original final schedule and the new final schedule (Δ). Furthermore, this difference is also represented as the relative individual gain score (%).

The results of a one-sided t-test for paired samples showed that the mean estimated total quality value for the original final schedules (Q^o) was lower (t-value=6.81, df=7, $p<0.0005$) than this mean for the new final schedules (Q^n). This means that quality indication scheduling significantly increased the quality of the final schedules. These results reject the null hypothesis, which stated that this difference would be zero (i.e. $H_0 : Q^n - Q^o = 0$), and confirm the alternative hypothesis, which stated that this difference would be greater than zero (i.e. $H_1: Q^n - Q^o > 0$). These findings clearly support the effectiveness of the quality indication scheduling approach.

However, it could be argued that the significant results of the scheduling experiment are (partially) caused by the large number of available shifts in the

initial schedule compared with the number of required shifts. To deal with this criticism, one nurse scheduler arranged a nursing schedule on the basis of a less flexible initial schedule. Also in this case, quality indication scheduling could be used to increase the estimated total nursing schedule quality. Appendix C shows these results.

Table 7.7 FACTOR VALUES OF THE NEW FINAL SCHEDULES

	C	O	P	H	T	Q	Δ	%
1	1.00	0.41	0.49	1.00	0.55	6.9	2.4	53
2	1.00	0.24	0.62	0.39	1.00	6.5	2.1	48
3	1.00	0.44	0.55	0.55	0.49	6.1	1.3	27
4	1.00	0.37	0.50	0.46	0.55	5.8	0.5	9
5	1.00	1.00	0.62	0.55	0.55	7.4	1.2	19
6	1.00	0.60	0.50	0.34	0.65	6.2	1.5	32
7	1.00	0.38	0.51	0.46	0.65	6.0	1.6	36
8	1.00	0.38	0.53	0.36	0.65	5.8	1.0	21
mean	1.00	0.48	0.54	0.51	0.64	6.3	1.5	31
σ	0.00	0.23	0.05	0.21	0.16	0.6	0.6	15

The rearranging of the original final schedules into the new final schedules took most nurse schedulers about twenty minutes. Table 7.8 shows the total scheduling time in the new situation.

Table 7.9 shows the numbers of occurrences for each of the low-quality schedule patterns per rearranged nursing schedule. In this new situation, the number of occurrences of most low-quality schedule patterns shows a large decrease compared to the original situation. The low-healthiness schedule pattern of ‘an evening shift followed by a day shift’ (H7) shows the largest decrease in number of occurrences. Also in the new situation, the low-quality schedule pattern of ‘day over-qualification’ (O4) still has the most occurrences. Furthermore, the number of occurrences of two low-quality schedule patterns (O1 and H3) increased by one or two as a result of the re-arrangement.

In total, the number of occurrences of the low-quality schedule pattern

decreased from 467 to 256, which is a decrease of forty-five percent. This means that, on average, a nurse scheduler was able to reduce the number of low-quality schedule patterns to almost half the original number on the basis of the information on quality factor values.

Table 7.8 TOTAL SCHEDULING TIME IN MINUTES IN THE NEW SITUATION

	scheduler								mean	σ
	1	2	3	4	5	6	7	8		
time	78	129	114	80	114	127	125	77	106	23

Table 7.10 shows the summarized number of low-quality schedule patterns per quality factor for the new final schedules. The summarizations show a very large decrease in low-healthiness schedule patterns. Apparently, the application of quality indication scheduling enables nurse schedulers to increase the healthiness of nursing schedules. Another demonstrated advantage of quality indication scheduling is the resulting absence of incompleteness.

Figure 7.4 shows one of the new final schedules. This new final schedule only contains six low-quality schedule patterns, while the original final schedule contains twenty-three of these patterns.

The new final schedule shown in figure 7.4 has the highest total quality value compared with the other new final schedules. This schedule has acceptable values on all quality indicators, including healthiness. This can be illustrated by the fact that all seven occurrences of an evening shift followed by a day shift in the original final schedule (see figure 7.3) are successfully removed in this new final schedule.

7.2.3 Randomized pre-test post-test control group design

As described in the previous subsection, the results of the scheduling experiment showed that the approach of quality indication scheduling is effective. However, this conclusion could be criticized for the lack of a control group (Neale & Liebert, 1986, pp. 134-147). Therefore, the data presented above were reanalyzed in such

a way that the scheduling experiment fulfilled this requirement of a control group. This was done by using (ad hoc) a randomized pre-test post-test control

Table 7.9a NUMBERS OF OCCURRENCES OF LOW-QUALITY SCHEDULE PATTERNS IN NEW FINAL SCHEDULES

	schedules										
	1	2	3	4	5	6	7	8	total	Δ	%
completeness:											
day incompleteness	0	0	0	0	0	0	0	0	0	- 2	- 100
evening incompleteness	0	0	0	0	0	0	0	0	0	- 3	- 100
night incompleteness	0	0	0	0	0	0	0	0	0	- 3	- 100
optimality:											
day under-qualification	0	6	2	3	0	1	2	3	17	+2	+ 13
evening under-qualification	0	3	0	0	0	0	1	0	4	0	0
night under-qualification	0	0	0	0	0	0	0	0	0	- 3	- 100
day over-qualification	11	23	9	10	0	0	12	13	78	- 15	- 16
evening over-qualification	0	13	0	7	0	0	0	2	22	- 4	- 15
night over-qualification	0	0	0	0	0	0	0	0	0	0	0
proportionality:											
single day off	0	0	1	1	0	2	1	0	5	- 15	- 75
double weekend on	5	1	1	2	1	2	3	4	19	- 7	- 27
triple weekend on	1	0	0	1	0	0	0	0	2	- 1	- 33

Table 7.9b NUMBERS OF OCCURRENCES OF LOW-QUALITY SCHEDULE PATTERNS IN NEW FINAL SCHEDULES

	schedules								total	Δ	%
	1	2	3	4	5	6	7	8			
healthiness:											
too many consecutive days on	0	0	0	1	0	3	0	0	4	- 14	- 78
too many consecutive day shifts	0	5	0	0	0	0	0	4	9	- 14	- 61
too many consecutive evening shifts	0	0	0	1	0	1	0	0	2	+ 1	+ 100
too many consecutive night shifts	0	12	0	0	0	24	0	0	36	- 4	- 8
too few days off after night shifts	0	2	2	4	2	0	2	6	18	- 21	- 54
single day on	0	0	0	0	0	0	0	2	0	- 2	- 100
evening shift followed by day shift	0	0	0	1	0	5	5	16	27	- 82	- 75
continuity:											
semi-discontinuity	3	0	2	0	3	1	1	1	11	- 16	- 60
full-discontinuity	0	0	1	1	0	0	0	0	2	- 8	- 80
total	20	65	18	32	6	39	27	49	256	- 211	- 45
Δ	- 24	- 17	- 10	- 35	- 17	- 34	- 22	- 52			
%	- 55	- 21	- 36	- 52	- 74	- 47	- 45	- 51			

Figure 7.4 THE NEW FINAL SCHEDULE REARRANGED BY NURSE SCHEDULER NUMBER FIVE

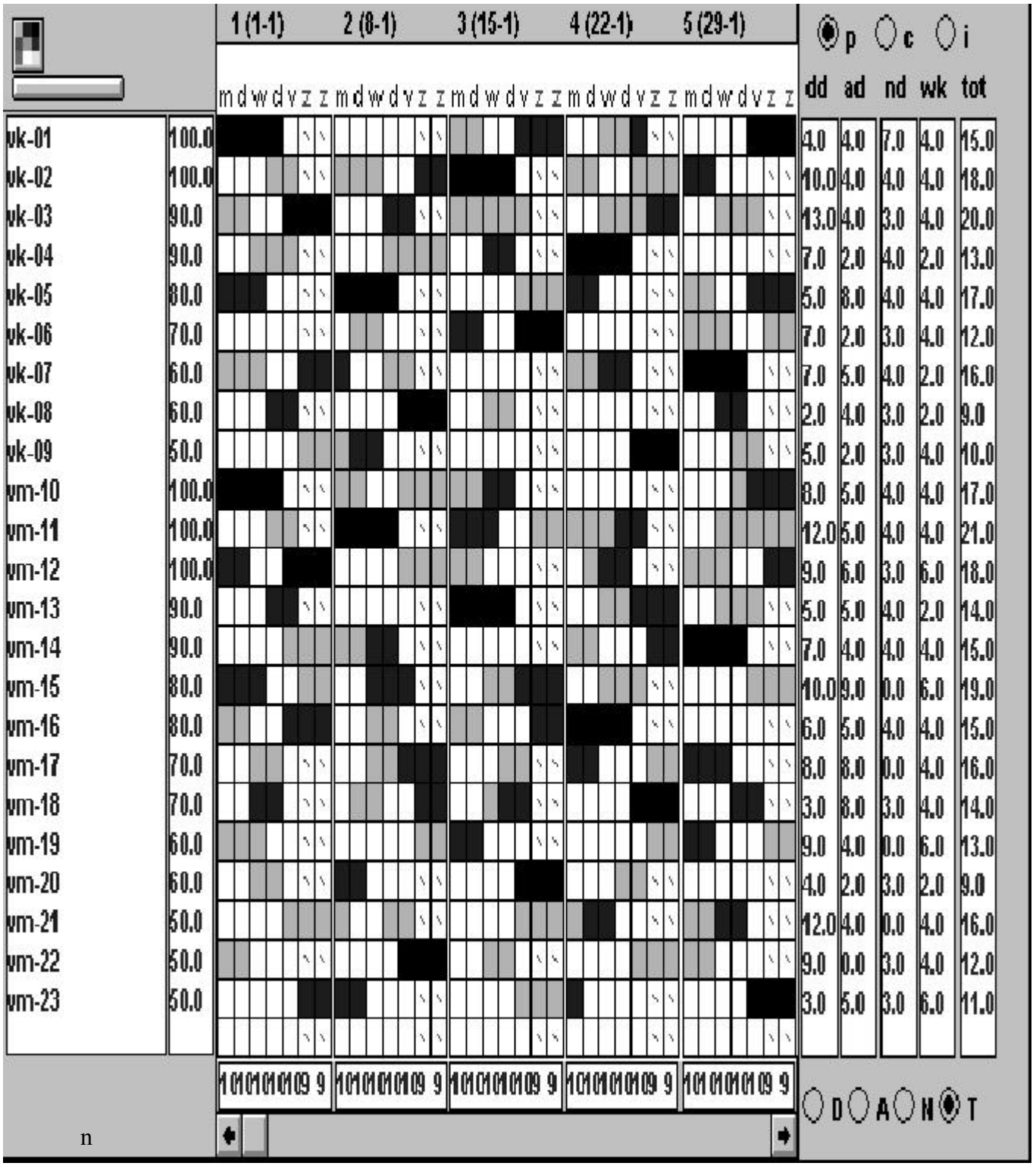


Table 7.10 SUMMARIZED NUMBER OF LOW-QUALITY SCHEDULE PATTERNS PER QUALITY FACTOR IN NEW FINAL SCHEDULES

quality factor	schedules								total	Δ	%
	1	2	3	4	5	6	7	8			
C	0	0	0	0	0	0	0	0	0	- 8	- 100
O	11	45	11	20	0	1	15	18	121	- 20	- 14
P	6	1	2	4	1	4	4	4	26	- 23	- 47
H	0	19	2	7	2	33	7	26	96	- 136	- 59
T	3	0	3	1	3	1	1	1	13	- 24	- 65

Table 7.11 RESULTS OF THE FIRST PRE-TEST—POST-TEST CONTROL GROUP DESIGN

	mean value of Q				mean scheduling time			
	C		E		C		E	
	mean	σ	mean	σ	mean	σ	mean	σ
original situation	4.8	0.4	5.0	0.8	98	20	89	19
new situation	4.8	0.4	6.6	0.7	98	20	108	21

C = control group
E = experimental group

group design (Neale & Liebert, 1986, pp. 147-149). This design was applied twice. In the first pre-test post-test control group design, all schedulers with an even number were assigned to the control group (C), while all schedulers with an odd number were assigned to the experimental group (E). In this design, only the experimental group received quality indication in the post-test condition. In the pre-test condition, neither group received quality indication. And for the control group, the post-test condition and the pre-test condition were identical. Table 7.11 shows the results of this first pre-test post-test control group design.

The results of a one-sided t-test for paired samples showed that, in the new situation, the mean estimated total quality value for the experimental group significantly exceeds this mean for control group (t-value=3.82, df=3, p=0.016). The amount of time required in the new situation did not differ significantly (t-value=0.59, df=3, p=0.299).

In the second pre-test post-test control group design, the situation was reversed. Now, all schedulers with an odd number were assigned to the control group (C), while all schedulers with an even number were assigned to the experimental group (E). Table 7.12 shows the results of this second pre-test post-test control group design.

Table 7.12 RESULTS OF THE SECOND PRE-TEST—POST-TEST CONTROL GROUP DESIGN

	mean value of Q				mean scheduling time			
	C		E		C		E	
	mean	σ	mean	σ	mean	σ	mean	σ
original situation	5.0	0.8	4.8	0.4	89	19	98	20
new situation	5.0	0.8	6.1	0.3	89	19	103	29

C = control group
E = experimental group

Again, the results of a one-side t-test for paired samples showed that, in the new situation, the mean estimated total quality value for the experimental group exceeds this mean for control group (t-value=2.62, df=3, p=0.040). The amount of time required in the new situation did not differ significantly (t-value=0.68, df=3, p=0.274).

The reanalysis of the results of the scheduling experiment emulating a randomized pre-test post-test control group design also showed an improvement of nursing schedule quality caused by the use of quality indication. This improvement is significant when an error tolerance of five percent is used. The results of this reanalysis show the validity of the results of the scheduling experiment, and it refutes criticism based on the lack of a control group.

7.3 CONCLUSIONS OF THE SCHEDULING EXPERIMENT

The objective of the scheduling experiment is to test the hypothesis of effectiveness. This hypothesis states that the task of nurse scheduling can be effectively supported by means of quality indication. The results of the scheduling experiment showed a significantly higher quality value for nursing schedules arranged on the basis of quality indication, compared to nursing schedules arranged without this additional information. To be more specific, all nurse schedulers involved in this experiment used the quality indication, which resulted in an improvement of nursing schedule quality value of about thirty percent and an average decrease of low-quality schedule patterns of forty-five percent. Therefore, the results of the scheduling experiment clearly support the hypothesis of effectiveness. This provides a positive answer to the fourth and last research question described in the third chapter: “Does quality indication improve the quality of nursing schedules?”.